
Part 29—Airworthiness Standards: Transport Category Rotorcraft

This change incorporates Amendment 29-36, Airworthiness Standards: Rotorcraft Engine Burst Protection, adopted October 6, 1995. This amendment revises §§ 29.901(c) and 29.903(d).

Bold brackets enclose the most recently changed or added material in these particular sections. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

Page Control Chart

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Suggest filing this transmittal at the beginning of the FAR. It will provide a method for determining that all changes have been received as listed in the current edition of AC 00-44, Status of Federal Aviation Regulations, and a check for determining if the FAR contains the proper pages.

(Published in 68 FR 55774, November 2, 1999)

SUMMARY: This final rule amends the airworthiness regulations to require that manufacturers of new design transport category rotorcraft minimize the adverse effects of a turbine engine rotor failure. Turbine engine rotor failures have occurred resulting in the release of high energy engine rotor fragments or other engine component fragments. These fragments have damaged critical rotorcraft structures, systems, controls, and adjacent engines, as well as caused serious or fatal injuries to passengers and crewmembers. This action is intended to minimize these hazards.

FOR FURTHER INFORMATION CONTACT: Mr. Ron Dalton, Federal Aviation Administration (FAA), Rotorcraft Directorate, Rotorcraft Standards Staff, Fort Worth, TX 76193-0110; telephone (817) 222-5127.

SUPPLEMENTARY INFORMATION:

Background

A Notice of Proposed Rulemaking (NPRM) No. 89-29 was published in the *Federal Register* on October 17, 1989 (54 FR 42716), and the comment period was reopened by NPRM No. 89-29A, published in the *Federal Register* on January 14, 1993 (58 FR 4566). These NPRMs proposed to amend 14 CFR part 29 (part 29) to require designs that would minimize the hazards associated with the failures of turbine engine (engine) rotors in newly designed transport category rotorcraft. Since there has not been an adverse service history for normal category rotorcraft, similar changes to 14 CFR part 27 were not proposed. If an adverse service history for normal category rotorcraft should develop, similar changes to 14 CFR part 27 would be considered.

National Transportation Safety Board (NTSB) Recommendation

This amendment responds to NTSB Safety Recommendation A-84-60 dated June 14, 1984. The NTSB recommends that the FAA review engine compartment design of all U.S. type certificated "multiengine helicopters with regard to the probability that an uncontained engine failure will result in catastrophic damage to the drive train, electrical, and/or fuel and hydraulic system components." This rule responds directly to the recommendation.

Provisions of NPRM Nos. 89-29 and 89-29A

NPRM No. 89-29 proposed changes to 14 CFR 29.901 and 29.903 (§§ 29.901 and 29.903) to increase the safety margin by requiring designs that minimize the hazards to transport category rotorcraft in the event of an engine rotor failure. The required designs may include items such as separation or duplication of critical components, engine location to reduce risk, or placement of critical components in benign locations. Containment provisions for one or more stages of the engine were not specifically proposed by that proposal; however, as stated in Notice No. 89-29A, containment provisions could be one of several effective means of compliance.

NPRM No. 89-29A reopened the comment period and invited comments only on the issues of engine rotor containment and the use of advanced composite material. NPRM No. 89-29A also provided further clarification of the intent of the NPRM. Specifically, the FAA clarified that when evaluating an applicant's proposed method of compliance, the FAA would consider the available technology and the costs required to minimize the hazards from an engine rotor failure. The FAA also noted that engine rotor containment features have not been specifically required in airplane designs that comply with 14 CFR 23.903 and 25.903 (§§ 23.903 and 25.903). Likewise, containment features would not be specifically required in rotorcraft to minimize the hazards of an engine rotor failure. The guidance contained in Advisory Circular (AC) 20-128, "Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor and Fan Blade Failures," is applicable to the requirements of § 29.903 in the same way it now applies to §§ 23.903 and 25.903 for airplanes. Furthermore, the

of composite materials could be one means of compliance. Since this was unclear to the three commenters, several meetings with representatives of AIA were held. Subsequently, the FAA issued NPRM No. 89-29A, which reopened the comment period with a further explanation of the proposed amendments.

Two comments were received in response to NPRM No. 89-29A. Neither commenter addressed the issues of engine rotor containment or the use of advanced composite material. As stated earlier in this document, request for comments on these issues was the reason for reopening the comment period for NPRM No. 89-29A.

One commenter simply restated an opinion submitted in response to NPRM No. 89-29 that minimizing hazards resulting from engine rotor failures in helicopters is impractical. The other commenter disagreed with the proposed wording of § 29.903. The commenter observed that the wording, "Design procedures must be taken to minimize the hazards to the rotorcraft in the event of an engine rotor failure . . .," has been applied to fixed wing aircraft for some time with little or no success. The FAA disagrees that minimizing the hazards of engine rotor failure is impractical or that compliance with similar requirements for airplanes has not been successful. Based on a review of rotorcraft service history and engineering studies, the FAA concludes that the need for this amendment has been adequately demonstrated and shown to be practical for rotorcraft.

The proposed change to § 29.903 was inadvertently stated as revising paragraph (f). The correct cite should have been to paragraph § 29.903(d). This error is corrected in this final rule. The FAA adopts the changes to §§ 29.901 and 29.903 as proposed, except for the noted paragraph correction.

Regulatory Evaluation Summary

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) Will generate benefits that justify its costs and is not a "significant regulatory action" as defined in the Executive Order; (2) is not significant as defined in DOT's Regulatory Policies and Procedures; (3) will not have a significant impact on a substantial number of small entities; and (4) will not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

Costs

On the basis of estimates from FAA and industry, incremental development and certification costs are estimated to be \$33,600 per type certification project. Incremental manufacturing costs are estimated to be \$560 for each single-engine rotorcraft and \$1,120 for each twin-engine rotorcraft.

In addition to increasing the acquisition costs of newly certificated rotorcraft, the rule could result in weight penalties. FAA and industry analyses suggest that this weight penalty could be as much as 6 pounds per engine. Each additional pound of weight increases fuel consumption for an average part 29 rotorcraft by approximately 0.0597 gallons per flight hour. Assuming 527 flight hours per year for an average part 29 rotorcraft, compliance with the rule will increase annual fuel consumption by about 31.46 gallons per pound of additional weight. Using a forecast jet fuel price of \$1.78 per gallon, annual fuel costs could rise by about \$56 per additional pound, or about \$336 per single engine transport rotorcraft, or \$672 per twin-engine transport rotorcraft, respectively, per year.

Assuming a production run of 15 years during which 10 aircraft are produced per year and assuming that each rotorcraft has an operating life of 15 years, the average costs of compliance are \$5,824 for a single-engine rotorcraft and \$11,425 for a twin-engine rotorcraft. Applying a discount rate of 7 percent, the average costs of compliance for single-engine and twin-engine rotorcraft are \$2,271 and \$4,326, respectively, at present value.

damage to or loss of the aircraft. In the remaining 21 cases, damage and/or injuries were not directly attributed to the uncontained failure, but were ascribed to other causes. These 21 cases are excluded from the benefit calculations.

Assuming 527 annual airborne hours for an average part 29 rotorcraft, FAA estimates the annual average probabilities that a transport rotorcraft will be substantially damaged or destroyed as a direct result of an uncontained turbine rotor burst are 0.00012 and 0.00066 for single- and twin-engine rotorcraft respectively.

The benefits of prevented rotorcraft damage and loss are the avoided replacement and repair costs that would otherwise be incurred in the absence of compliance with this rule. In this analysis, average new unit costs of single- and twin-engine part 29 rotorcraft are estimated to be \$3.200 million and \$4.275 million respectively. Replacement cost is assumed to equal one-half the original new list price, and restoration cost is estimated to be 13 percent of replacement cost. The expected annual per-aircraft benefit of prevented rotorcraft damage and loss is the weighted sum of replacement and restoration costs where the weights are determined by the respective probabilities of aircraft damage or loss. The FAA/SAE data included 2 single-engine rotorcraft destroyed, and 4 single-engine rotorcraft damaged, in 26.6 million flight hours; it also included 4 twin-engine rotorcraft destroyed, and 7 twin-engine rotorcraft damaged, in 8.8 million flight hours. The FAA concludes that the annual average benefits of prevented rotorcraft damage are about \$80 for single-engine rotorcraft and \$628 for twin-engine rotorcraft.

Under the same production run, operating life, and discount rate assumptions used to derive average costs, the FAA estimates the expected benefits of prevented aircraft damage/loss are \$1,197 per single-engine rotorcraft and \$9,413 per twin-engine rotorcraft, or \$412 and \$3,243 at present value, respectively.

Benefits of Prevented Injuries and Fatalities

Using data from the FAA and the NTSB, the FAA identified five fatalities and eight injuries resulting from the uncontained events documented by the FAA/SAE Committee. Two of the fatalities occurred as the result of a failed autorotation landing involving a single-engine category B rotorcraft. In this case, the rotor burst did not directly cause the failed landing and, therefore, the fatalities were excluded from this analysis. The remaining three fatalities and three of the injuries occurred in twin-engine rotorcraft. Five of the injuries occurred in single-engine rotorcraft. Based on the available casualty history, the FAA concludes that in 8.8 million twin-engine part 29 rotorcraft flight hours, the rule could prevent 3 fatalities, 1 serious injury, and 2 minor injuries. The FAA also concludes that in 26.6 million single-engine part 29 rotorcraft flight hours, the rule could prevent 2 serious injuries and 3 minor injuries.

Assuming 527 annual flight hours for a typical part 29 rotorcraft, and based on costs of \$2.5 million, \$640,000 and \$5,000 per each fatality, serious injury, and minor injury, respectively, the average annual benefits derived from avoiding fatalities and injuries are about \$488 per twin-engine transport rotorcraft and \$26 per single-engine rotorcraft.

Using the production run, operating life, discount rate, and other assumptions listed above, the FAA estimates that the benefits of avoided injuries and fatalities are \$385 per single-engine rotorcraft, and \$7,321 per twin-engine rotorcraft, or \$133 and \$2,523 at present value, respectively.

Cost-Benefit Summary

With respect to twin-engine rotorcraft, the benefits of avoided aircraft damage and avoided fatalities and injuries are expected to exceed the estimated development, certification, manufacturing and operating costs of the rule by a margin of roughly 1.3 to 1 (\$5,766 to \$4,326 in present value terms).

The benefits for single-engine rotorcraft, however, are less clear. Because part 29 rotorcraft type-certificate applications for single engine rotorcraft are unlikely, FAA's economic analysis of single-engine types concludes that the rule will be cost-beneficial only if design and manufacturing costs are modest. It should be noted that the analysis of the benefits of prevented injuries and fatalities, summarized above, does not assume that a fatality from operation of a single-engine part 29 rotorcraft would be prevented;

The Regulatory Flexibility Act (RFA) of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis if a rule is expected to have a "significant economic impact on a substantial number of small entities."

Based on the standards and thresholds specified in implementing FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, the FAA has determined that the rule will not have a significant impact on a substantial number of small entities, because there are no "small entity" rotorcraft manufacturers, as defined in the order.

Federalism Implications

The regulations herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this regulation will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed above, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the RFA. This regulation is not considered to be significant under DOT Order Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A final regulatory evaluation of the regulation, including a final Regulatory Flexibility Determination and International Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

The Amendment

Accordingly, the FAA amends part 29 of the Federal Aviation Regulations (14 CFR part 29) effective January 31, 1996.

The authority citation for part 29 is revised to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls.

(b) For each powerplant installation—

(1) The installation must comply with—

(i) The installation instructions provided under § 33.5 of this chapter; and

(ii) The applicable provisions of this subpart.

(2) Each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls for the range of temperature and altitude for which approval is requested.

(3) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(4) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft; and

(5) Axial and radial expansion of turbine engines may not affect the safety of the installation.

(6) Design precautions must be taken to minimize the possibility of incorrect assembly of components and equipment essential to safe operation of the rotorcraft, except where operation with the incorrect assembly can be shown to be extremely improbable.

(c) [For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the rotorcraft except that the failure of structural elements need not be considered if the probability of any such failure is extremely remote.]

have an approved type certificate. Reciprocating engines for use in helicopters must be qualified in accordance with § 33.49(d) of this chapter or be otherwise approved for the intended usage.

(b) *Category A: Engine isolation.* For each category A rotorcraft, the powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure of any system that can affect any engine, will not—

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action, other than normal pilot action with primary flight controls, by any crewmember to maintain safe operation.

(c) *Category A: Control of engine rotation.* For each category A rotorcraft, there must be a means for stopping the rotation of any engine individually in flight, except that, for turbine engine installations, the means for stopping the engine need be provided only where necessary for safety. In addition—

(1) Each component of the engine stopping system that is located on the engine side of the firewall, and that might be exposed to fire, must be at least fire resistant; or

(2) Duplicate means must be available for stopping the engine and the controls must be where all are not likely to be damaged at the same time in case of fire.

(d) [Turbine engine installation. For turbine engine installations—

[(1) Design precautions must be taken to minimize the hazards to the rotorcraft in the event of an engine rotor failure; and

[(2) The powerplant systems associated with engine control devices, systems, and instrumenta-

onstrated throughout a flight envelope for the rotorcraft.

(3) Following the in-flight shutdown of all engines, in-flight engine restart capability must be provided.

(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-22, Eff. 3/26/84); (Amdt. 29-26, Eff. 10/3/88); (Amdt. 29-31, Eff. 10/22/90); [(Amdt. 29-36, Eff. 1/31/96)]

§ 29.907 Engine vibration.

(a) Each engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft.

(b) The addition of the rotor and the rotor drive system to the engine may not subject the principal rotating parts of the engine to excessive vibration stresses. This must be shown by a vibration investigation.

§ 29.908 Cooling fans.

For cooling fans that are a part of a powerplant installation the following apply:

(a) *Category A.* For cooling fans installed in Category A rotorcraft, it must be shown that a fan blade failure will not prevent continued safe flight either because of damage caused by the failed blade or loss of cooling air.

(b) *Category B.* For cooling fans installed in category B rotorcraft, there must be means to protect the rotorcraft and allow a safe landing if a fan blade fails. It must be shown that—

(1) The fan blade would be contained in the case of a failure;

(2) Each fan is located so that a fan blade failure will not jeopardize safety; or

(3) Each fan blade can withstand an ultimate load of 1.5 times the centrifugal force expected in service, limited by either—

(i) The highest rotational speeds achievable under uncontrolled conditions; or

(ii) An overspeed limiting device.

§ 29.917 Design.

(a) *General.* The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

(b) *Arrangement.* Rotor drive systems must be arranged as follows:

(1) Each rotor drive system of multi-engine rotorcraft must be arranged so that each rotor necessary for operation and control will continue to be driven by the remaining engines if any engine fails.

(2) For single-engine rotorcraft, each rotor drive system must be so arranged that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(3) Each rotor drive system must incorporate a unit for each engine to automatically disengage that engine from the main and auxiliary rotors if that engine fails.

(4) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(5) If the rotors must be phased for intermeshing, each system must provide constant and positive phase relationship under any operating condition.

(6) If a rotor dephasing device is incorporated, there must be means to keep the rotors locked in proper phase before operation.

[(Amdt. 29-12, Eff. 2/1/77)]

§ 29.921 Rotor brake.

If there is a means to control the rotation of the rotor drive system independently of the engine, any limitations on the use of that means must be

section, for at least 200 hours plus the time required to meet the requirements of paragraphs (b)(2), (b)(3), and (k) of this section. These tests must be conducted as follows:】

(1) Ten-hour test cycles must be used, except that the test cycle must be extended to include the OEI test of paragraphs (b)(2) and (k) of this section, if OEI ratings are requested.

(2) The tests must be conducted on the rotorcraft.

(3) The test torque and rotational speed must be—

(i) Determined by the powerplant limitations; and

(ii) Absorbed by the rotors to be approved for the rotorcraft.

(b) *Endurance tests, takeoff run.* The takeoff run must be conducted as follows:

(1) 【Except as prescribed in paragraphs (b)(2) and (b)(3) of this section, the takeoff torque run must consist of 1 hour of alternate runs of 5 minutes at takeoff torque and the maximum speed for use with takeoff torque, and 5 minutes at as low an engine idle speed as practicable. The engine must be declutched from the rotor drive system, and the rotor brake, if furnished and so intended, must be applied during the first minute of the idle run. During the remaining 4 minutes of the idle run, the clutch must be engaged so that the engine drives the rotors at the minimum practical r.p.m. The engine and the rotor drive system must be accelerated at the maximum rate. When declutching the engine, it must be decelerated rapidly enough to allow the operation of the overrunning clutch.】

(2) For helicopters for which the use of a 2½-minute OEI rating is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section, except for the third and sixth runs for which the takeoff torque and the maximum speed for use with takeoff torque are prescribed in that paragraph. For these runs, the following apply:

(i) Each run must consist of at least one period of 2½ minutes with takeoff torque and

【(3) For multiengine, turbine-powered rotorcraft for which the use of 30-second/2-minute OEI power is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section except for the following:

【(i) Immediately following any one 5-minute power-on run required by paragraph (b)(1) of this section, each power source must simulate a failure, in turn, and apply the maximum torque and the maximum speed for use with 30-second OEI power to the remaining affected drive system power inputs for not less than 30 seconds, followed by application of the maximum torque and the maximum speed for use with 2-minute OEI power for not less than 2 minutes. At least one run sequence must be conducted from a simulated “flight idle” condition. When conducted on a bench test, the test sequence must be conducted following stabilization at takeoff power.

【(ii) For the purpose of this paragraph, an affected power input includes all parts of the rotor drive system which can be adversely affected by the application of higher or asymmetric torque and speed prescribed by the test.

【(iii) This test may be conducted on a representative bench test facility when engine limitations either preclude repeated use of this power or would result in premature engine removals during the test. The loads, the vibration frequency, and the methods of application to the affected rotor drive system components must be representative of rotorcraft conditions. Test components must be those used to show compliance with the remainder of this section.】

(c) *Endurance tests, maximum continuous run.* Three hours of continuous operation at maximum continuous torque and the maximum speed for use with maximum continuous torque must be conducted as follows:

(1) The main rotor controls must be operated at a minimum of 15 times each hour through the main rotor pitch positions of maximum vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust

ing torque.

(3) Each maximum control position must be held for at least 10 seconds, and the rate of change of control position must be at least as rapid as that for normal operation.

(d) *Endurance tests; 90 percent of maximum continuous run.* One hour of continuous operation at 90 percent of maximum continuous torque and the maximum speed for use with 90 percent of maximum continuous torque must be conducted.

(e) *Endurance tests; 80 percent of maximum continuous run.* One hour of continuous operation at 80 percent of maximum continuous torque and the minimum speed for use with 80 percent of maximum continuous torque must be conducted.

(f) *Endurance tests; 60 percent of maximum continuous run.* Two hours or, for helicopters for which the use of either 30-minute OEI power or continuous OEI power is requested, 1 hour of continuous operation at 60 percent of maximum continuous torque and the minimum speed for use with 60 percent of maximum continuous torque must be conducted.

(g) *Endurance tests; engine malfunctioning run.* It must be determined whether malfunctioning of components, such as the engine fuel or ignition systems, or whether unequal engine power can cause dynamic conditions detrimental to the drive system. If so, a suitable number of hours of operation must be accomplished under those conditions, 1 hour of which must be included in each cycle, and the remaining hours of which must be accomplished at the end of the 20 cycles. If no detrimental condition results, an additional hour of operation in compliance with paragraph (b) of this section must be conducted in accordance with the run schedule of paragraph (b)(1) of this section without consideration of paragraph (b)(2) of this section.

(h) *Endurance tests; overspeed run.* One hour of continuous operation must be conducted at maximum continuous torque and the maximum power-on overspeed expected in service, assuming that speed and torque limiting devices, if any, function properly.

(i) *Endurance tests; rotor control positions.* When the rotor controls are not being cycled during

cent.

(3) For the right thrust component, 10 percent.

(4) For the left thrust component, 10 percent.

(5) For the aft thrust component, 10 percent.

(j) *Endurance tests, clutch and brake engagements.* A total of at least 400 clutch and brake engagements, including the engagements of paragraph (b) of this section, must be made during the takeoff torque runs and, if necessary, at each change of torque and speed throughout the test. In each clutch engagement, the shaft on the driven side of the clutch must be accelerated from rest. The clutch engagements must be accomplished at the speed and by the method prescribed by the applicant. During deceleration after each clutch engagement, the engines must be stopped rapidly enough to allow the engines to be automatically disengaged from the rotors and rotor drives. If a rotor brake is installed for stopping the rotor, the clutch, during brake engagements, must be disengaged above 40 percent of maximum continuous rotor speed and the rotors allowed to decelerate to 40 percent of maximum continuous rotor speed, at which time the rotor brake must be applied. If the clutch design does not allow stopping the rotors with the engine running, or if no clutch is provided, the engine must be stopped before each application of the rotor brake, and then immediately be started after the rotors stop.

(k) *Endurance tests, OEI power run.*

(1) *30-minute OEI power run.* For rotorcraft for which the use of 30-minute OEI power is requested, a run at 30-minute OEI torque and the maximum speed for use with 30-minute OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for a 30-minute period.

(2) *Continuous OEI power run.* For rotorcraft for which the use of continuous OEI power is requested, a run at continuous OEI torque and the maximum speed for use with continuous OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for 1 hour.

their service lives must be determined by fatigue tests or by other acceptable methods. In addition, a level of safety equal to that of the main rotors must be provided for—

(1) Each component in the rotor drive system whose failure would cause an uncontrolled landing;

(2) Each component essential to the phasing of rotors on multirotor rotorcraft, or that furnishes a driving link for the essential control of rotors in autorotation; and

(3) Each component common to two or more engines on multiengine rotorcraft.

(n) *Special tests.* Each rotor drive system designed to operate at two or more gear ratios must be subjected to special testing for durations necessary to substantiate the safety of the rotor drive system.

(o) Each part tested as prescribed in this section must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(p) *Endurance tests; operating lubricants.* To be approved for use in rotor drive and control systems, lubricants must meet the specifications of lubricants used during the tests prescribed by this section. Additional or alternate lubricants may be qualified by equivalent testing or by comparative analysis of lubricant specifications and rotor drive and control system characteristics. In addition—

(1) At least three 10-hour cycles required by this section must be conducted with transmission and gearbox lubricant temperatures, at the location prescribed for measurement, not lower than the maximum operating temperature for which approval is requested;

(2) For pressure lubricated systems, at least three 10-hour cycles required by this section must be conducted with the lubricant pressure, at the location prescribed for measurement, not higher than the minimum operating pressure for which approval is requested; and

(3) The test conditions of paragraphs (p)(1) and (p)(2) of this section must be applied simultaneously and must be extended to include

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) If turbine engine torque output to the transmission can exceed the highest engine or transmission torque limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of—

(i) The maximum torque used in meeting § 29.923 plus 10 percent; or

(ii) The maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly.

(2) For multiengine rotorcraft under conditions associated with each engine, in turn, becoming inoperative, apply to the remaining transmission torque inputs the maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly. Each transmission input must be tested at this maximum torque for at least fifteen minutes.

(c) *Lubrication system failure.* For lubrication systems required for proper operation of rotor drive systems, the following apply:

(1) *Category A.* Unless such failures are extremely remote, it must be shown by test that any failure which results in loss of lubricant in any normal use lubrication system will not prevent continued safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant for continued flight, for at least 30 minutes after perception by the flightcrew of the lubrication system failure or loss of lubricant.

(2) *Category B.* The requirements of Category A apply except that the rotor drive system need only be capable of operating under autorotative conditions for at least 15 minutes.

and are shown to be reliable, their rotational speed limits need not be exceeded. These runs must be conducted as follows:

(1) Overspeed runs must be alternated with stabilizing runs of from 1 to 5 minutes duration each at 60 to 80 percent of maximum continuous speed.

(2) Acceleration and deceleration must be accomplished in a period not longer than 10 seconds (except where maximum engine acceleration rate will require more than 10 seconds), and the time for changing speeds may not be deducted from the specified time for the overspeed runs.

(3) Overspeed runs must be made with the rotors in the flattest pitch for smooth operation.

(e) The tests prescribed in paragraphs (b) and (d) of this section must be conducted on the rotorcraft and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(f) Each test prescribed by this section must be conducted without intervening disassembly and, except for the lubrication system failure test required by paragraph (c) of this section, each part tested must be in a serviceable condition at the conclusion of the test.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-17, Eff. 12/1/78; (Amdt. 29-26, Eff. 10/3/88)]]

§ 29.931 Shafting critical speed.

(a) The critical speeds of any shafting must be determined by demonstration except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power-on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operat-

joints whose lubrication is necessary for operation must have provision for lubrication.

§ 29.939 Turbine engine operating characteristics.

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and of the engine.

(b) The turbine engine air inlet system may not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine.

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the drive system associated with critical combinations of power, rotational speed, and control displacement.

[(Amdt. 29-2, Eff. 6/4/67); (Amdt. 29-12, Eff. 2/1/77)]]

FUEL SYSTEM

§ 29.951 General.

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine and auxiliary power unit functioning under any likely operating conditions, including the maneuvers for which certification is requested and during which the engine or auxiliary power unit is permitted to be in operation.

(b) Each fuel system must be arranged so that—

(1) No engine or fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F. and having 0.75 cc. of free water per gallon added and cooled to the most

fires to occupants following an otherwise survivable impact (crash landing), the fuel systems must incorporate the design features of this section. These systems must be shown to be capable of sustaining the static and dynamic deceleration loads of this section, considered as ultimate loads acting alone, measured at the system component's center of gravity without structural damage to system components, fuel tanks, or their attachments that would leak fuel to an ignition source.

(a) *Drop test requirements.* Each tank, or the most critical tank, must be drop-tested as follows:

- (1) The drop height must be at least 50 feet.
- (2) The drop impact surface must be nondeforming.
- (3) The tank must be filled with water to 80 percent of the normal, full capacity.
- (4) The tank must be enclosed in a surrounding structure representative of the installation unless it can be established that the surrounding structure is free of projections or other design features likely to contribute to rupture of the tank.
- (5) The tank must drop freely and impact in a horizontal position $\pm 10^\circ$.
- (6) After the drop test, there must be no leakage.

(b) *Fuel tank load factors.* Except for fuel tanks located so that tank rupture with fuel release to either significant ignition sources, such as engines, heaters, and auxiliary power units, or occupants is extremely remote, each fuel tank must be designed and installed to retain its contents under the following ultimate inertial load factors, acting alone.

(1) For fuel tanks in the cabin:

- (i) Upward—4g.
- (ii) Forward—16g.
- (iii) Sideward—8g.
- (iv) Downward—20g.

(2) For fuel tanks located above or behind the crew or passenger compartment that, if loosened, could injure an occupant in an emergency landing:

- (i) Upward—1.5g.
- (ii) Forward—8g.
- (iii) Sideward—2g.

unless hazardous relative motion of fuel system components to each other or to local rotorcraft structure is demonstrated to be extremely improbable or unless other means are provided. The couplings or equivalent devices must be installed at all fuel tank-to-fuel line connections, tank-to-tank interconnects, and at other points in the fuel system where local structural deformation could lead to the release of fuel.

(1) The design and construction of self-sealing breakaway couplings must incorporate the following design features:

(i) The load necessary to separate a breakaway coupling must be between 25 to 50 percent of the minimum ultimate failure load (ultimate strength) of the weakest component in the fluid-carrying line. The separation load must in no case be less than 300 pounds, regardless of the size of the fluid line.

(ii) A breakaway coupling must separate whenever its ultimate load (as defined in paragraph (c)(1)(i) of this section) is applied in the failure modes most likely to occur.

(iii) All breakaway couplings must incorporate design provisions to visually ascertain that the coupling is locked together (leak-free) and is open during normal installation and service.

(iv) All breakaway couplings must incorporate design provisions to prevent uncoupling or unintended closing due to operational shocks, vibrations, or accelerations.

(v) No breakaway coupling design may allow the release of fuel once the coupling has performed its intended function.

(2) All individual breakaway couplings, coupling fuel feed systems, or equivalent means must be designed, tested, installed, and maintained so that inadvertent fuel shutoff in flight is improbable in accordance with § 29.955(a) and must comply with the fatigue evaluation requirements of § 29.571 without leaking.

(3) Alternate, equivalent means to the use of breakaway couplings must not create a survivable impact-induced load on the fuel line to which it is installed greater than 25 to 50 percent of

or locally deformable attachments of fuel tanks and fuel system components to local rotorcraft structure must be used. The attachment of fuel tanks and fuel system components to local rotorcraft structure, whether frangible or locally deformable, must be designed such that its separation or relative local deformation will occur without rupture or local tear-out of the fuel tank or fuel system components that will cause fuel leakage. The ultimate strength of frangible or deformable attachments must be as follows:

(1) The load required to separate a frangible attachment from its support structure, or deform a locally deformable attachment relative to its support structure, must be between 25 and 50 percent of the minimum ultimate load (ultimate strength) of the weakest component in the attached system. In no case may the load be less than 300 pounds.

(2) A frangible or locally deformable attachment must separate or locally deform as intended whenever its ultimate load (as defined in paragraph (d)(1) of this section) is applied in the modes most likely to occur.

(3) All frangible or locally deformable attachments must comply with the fatigue requirements of § 29.571.

(e) *Separation of fuel and ignition sources.* To provide maximum crash resistance, fuel must be located as far as practicable from all occupiable areas and from all potential ignition sources.

(f) *Other basic mechanical design criteria.* Fuel tanks, fuel lines, electrical wires, and electrical devices must be designed, constructed, and installed, as far as practicable, to be crash resistant.

(g) *Rigid or semirigid fuel tanks.* Rigid or semirigid fuel tank or bladder walls must be impact and tear resistant.】

【(Amdt. 29-35, Eff. 11/2/94)】

§ 29.953 Fuel system independence.

(a) For category A rotorcraft—

(1) The fuel system must meet the requirements of § 29.903(b); and

tanks need not be provided for each engine.

§ 29.954 Fuel system lightning protection.

The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by—

(a) Direct lightning strikes to areas having a high probability of stroke attachment;

(b) Swept lightning strokes to areas where swept strokes are highly probable; and

(c) Corona and streamer at fuel vent outlets.

【(Amdt. 29-26, Eff. 10/3/88)】

§ 29.955 Fuel flow.

(a) *General.* The fuel system for each engine must provide the engine with at least 100 percent of the fuel required under all operating and maneuvering conditions to be approved for the rotorcraft, including, as applicable, the fuel required to operate the engines under the test conditions required by § 29.927. Unless equivalent methods are used, compliance must be shown by test during which the following provisions are met, except that combinations of conditions which are shown to be improbable need not be considered.

(1) The fuel pressure, corrected for accelerations (load factors), must be within the limits specified by the engine type certificate data sheet.

(2) The fuel level in the tank may not exceed that established as the unusable fuel supply for that tank under § 29.959, plus that necessary to conduct the test.

(3) The fuel head between the tank and the engine must be critical with respect to rotorcraft flight attitudes.

(4) The fuel flow transmitter, if installed, and the critical fuel pump (for pump-fed systems) must be installed to produce (by actual or simulated failure) the critical restriction to fuel flow to be expected from component failure.

(5) Critical values of engine rotational speed, electrical power, or other sources of fuel pump motive power must be applied.

(b) *Fuel transfer system.* If normal operation of the fuel system requires fuel to be transferred to another tank, the transfer must occur automatically via a system which has been shown to maintain the fuel level in the receiving tank within acceptable limits during flight or surface operation of the rotorcraft.

(c) *Multiple fuel tanks.* If an engine can be supplied with fuel from more than one tank, the fuel system, in addition to having appropriate manual switching capability, must be designed to prevent interruption of fuel flow to the engine, without attention by the flightcrew, when any tank supplying fuel to that engine is depleted of usable fuel during normal operation and any other tank that normally supplies fuel to that engine alone contains usable fuel.

[(Amdt. 29-2, Eff. 6/4/67); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.957 Flow between interconnected tanks.

(a) Where tank outlets are interconnected and allow fuel to flow between them due to gravity or flight accelerations, it must be impossible for fuel to flow between tanks in quantities great enough to cause overflow from the tank vent in any sustained flight condition.

(b) If fuel can be pumped from one tank to another in flight—

(1) The design of the vents and the fuel transfer system must prevent structural damage to tanks from overfilling; and

(2) There must be means to warn the crew before overflow through the vents occurs.

§ 29.959 Unusable fuel supply.

The unusable fuel supply for each tank must be established as not less than the quantity at which the first evidence of malfunction occurs under the most adverse fuel feed condition occurring under any intended operations and flight maneuvers involving that tank.

(d) If compliance with paragraph (b) of this section is shown in weather cold enough to interfere with the proper conduct of the test, each fuel tank surface, fuel line, and other fuel system parts subject to cold air must be insulated to simulate, insofar as practicable, flight in hot weather.

[(Amdt. 29-26, Eff. 10/3/88)]

§ 29.963 Fuel tanks: General.

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads to which it may be subjected in operation.

[(b)] [Each flexible fuel tank bladder or liner must be approved or shown to be suitable for the particular application and must be puncture resistant. Puncture resistance must be shown by meeting the TSO-C80, paragraph 16.0, requirements using a minimum puncture force of 370 pounds.]

[(c)] Each integral fuel tank liner must have facilities for inspection and repair of its interior.

[(d)] The maximum exposed surface temperature of all components in the fuel tank must be less by a safe margin than the lowest expected autoignition temperature of the fuel or fuel vapor in the tank. Compliance with this requirement must be shown under all operating conditions and under all normal or malfunction conditions of all components inside the tank.

[(e)] Each fuel tank installed in personnel compartments must be isolated by fume-proof and fuel-proof enclosures that are drained and vented to the exterior of the rotorcraft. The design and construction of the enclosures must provide necessary protection for the tank, must be crash resistant during a survivable impact in accordance with § 29.952, and must be adequate to withstand loads and abrasions to be expected in personnel compartments.]

(Amdt. 29-26, Eff. 10/3/88); [(Amdt. 29-35, Eff. 11/2/94)]

the rotorcraft structure, and each integral tank must be subjected to a pressure of 3.5 p.s.i. unless the pressure developed during maximum limit acceleration or emergency deceleration with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, must be applied to duplicate the acceleration loads as far as possible. However, the pressure need not exceed 3.5 p.s.i. on surfaces not exposed to the acceleration loading.

(c) Each nonmetallic tank with walls supported by the rotorcraft structure must be subjected to the following tests:

(1) A pressure test of at least 2.0 p.s.i. This test may be conducted on the tank alone in conjunction with the test specified in paragraph (c)(2) of this section.

(2) A pressure test, with the tank mounted in the rotorcraft structure, equal to the load developed by the reaction of the contents, with the tank full, during maximum limit acceleration or emergency deceleration. However, the pressure need not exceed 2.0 p.s.i. on surfaces not exposed to the acceleration loading.

(d) Each tank with large unsupported or unstiffened flat areas, or with other features whose failure or deformation could cause leakage, must be subjected to the following test or its equivalent:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation.

(2) The tank assembly must be vibrated for 25 hours while two-thirds full of any suitable fluid. The amplitude of vibration may not be less than one thirty-second of an inch unless otherwise substantiated.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the test frequency of vibration, in number of cycles per minute, must, unless a frequency based on a more rational analysis is used, be the number obtained by averaging the maximum and minimum power-on engine speeds (r.p.m.) for reciprocating engine powered rotor-

crafting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under paragraph (d)(3)(ii) and (iii), the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished in 25 hours at the frequency specified in paragraph (d)(3)(i) of this section.

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cycles per minute through an angle of 15° on both sides of the horizontal (30° total), about the most critical axis, for 25 hours. If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12½ hours.

[(Amdt. 29-13, Eff. 5/2/77)]

§ 29.967 Fuel tank installation.

(a) Each fuel tank must be supported so that tank loads are not concentrated on unsupported tank surfaces. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) The padding must be nonabsorbent or treated to prevent the absorption of fuel;

(3) If flexible tank liners are used, they must be supported so that they are not required to withstand fluid loads; and

(4) Each interior surface of tank compartments must be smooth and free of projections that could cause wear of the liner, unless—

(i) There are means for protection of the liner at those points; or

(ii) The construction of the liner itself provides such protection.

(b) Any spaces adjacent to tank surfaces must be adequately ventilated to avoid accumulation of fuel or fumes in those spaces due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes that prevent clogging and that prevent excessive pressure resulting from altitude changes. If flexible tank liners are installed, the venting arrangement for the spaces between the

(b) [Amdt. 29-35, Eff. 11/2/94]
(Amdt. 29-26, Eff. 10/3/88); [(Amdt. 29-35, Eff. 11/2/94)]

§ 29.969 Fuel tank expansion space.

Each fuel tank or each group of fuel tanks with interconnected vent systems must have an expansion space of not less than 2 percent of the combined tank capacity. It must be impossible to fill the fuel tank expansion space inadvertently with the rotorcraft in the normal ground attitude.

[(Amdt. 29-26, Eff. 10/3/88)]

§ 29.971 Fuel tank sump.

(a) Each fuel tank must have a sump with a capacity of not less than the greater of—

- (1) 0.10 percent of the tank capacity of—
- (2) One-sixteenth gallon.

(b) The capacity prescribed in paragraph (a) of this section must be effective with the rotorcraft in any normal attitude, and must be located so that the sump contents cannot escape through the tank outlet opening.

(c) Each fuel tank must allow drainage of hazardous quantities of water from each part of the tank to the sump with the rotorcraft in any ground attitude to be expected in service.

(d) Each fuel tank sump must have a drain that allows complete drainage of the sump on the ground.

[(Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.973 Fuel tank filler connection.

(a) [Each fuel tank filler connection must prevent the entrance of fuel into any part of the rotorcraft other than the tank itself during normal operations and must be crash resistant during a survivable impact in accordance with § 29.952(c). In addition—

- (1) Each filler must be marked as prescribed in § 29.1557(c)(1);
- (2) Each recessed filler connection that can retain any appreciable quantity of fuel must have

§ 29.975 Fuel tank vents and carburetor vapor vents.

(a) *Fuel tank vents.* Each fuel tank must be vented from the top part of the expansion space so that venting is effective under normal flight conditions. In addition—

(1) The vents must be arranged to avoid stoppage by dirt or ice formation;

(2) The vent arrangement must prevent siphoning of fuel during normal operation;

(3) The venting capacity and vent pressure levels must maintain acceptable differences of pressure between the interior and exterior of the tank during—

(i) Normal flight operation;

(ii) Maximum rate of ascent and descent; and

(iii) Refueling and defueling (where applicable);

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no point in any vent line where moisture can accumulate with the rotorcraft in the ground attitude or the level flight attitude, unless drainage is provided;

(6) No vent or drainage provision may end at any point—

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments; and

(7) [The venting system must be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover during landing, ground operations, or a survivable impact, unless a rollover is shown to be extremely remote.]

(b) *Carburetor vapor vents.* Each carburetor with vapor elimination connections must have a vent line to lead vapors back to one of the fuel tanks. In addition—

(1) Each vent system must have means to avoid stoppage by ice; and

§ 29.977 Fuel tank outlet.

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating engine powered airplanes, have 8 to 16 meshes per inch; and

(2) For turbine engine powered airplanes, prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

[(Amdt. 29-12, Eff. 2/1/77)]

§ 29.979 Pressure refueling and fueling provisions below fuel level.

(a) Each fueling connection below the fuel level in each tank must have means to prevent the escape of hazardous quantities of fuel from that tank in case of malfunction of the fuel entry valve.

(b) For systems intended for pressure refueling, a means in addition to the normal means for limiting the tank content must be installed to prevent damage to the tank in case of failure of the normal means.

(c) The rotorcraft pressure fueling system (not fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum pressure, including surge, that is likely to occur during fueling. The maximum surge pressure must be established with any combination of tank valves being either intentionally or inadvertently closed.

(d) The rotorcraft defueling system (not including fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum permissible defueling pressure (positive or negative) at the rotorcraft fueling connection.

[(Amdt. 29-12, Eff. 2/1/77)]

(2) Any component required for pump operation except the engine served by that pump.

(b) The following fuel pump installation requirements apply:

(1) When necessary to maintain the proper fuel pressure—

(i) A connection must be provided to transmit the carburetor air intake static pressure to the proper fuel pump relief valve connection; and

(ii) The gauge balance lines must be independently connected to the carburetor inlet pressure to avoid incorrect fuel pressure readings.

(2) The installation of fuel pumps having seals or diaphragms that may leak must have means for draining leaking fuel.

(3) Each drain line must discharge where it will not create a fire hazard.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.993 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure, valve actuation, and accelerated flight conditions.

(b) Each fuel line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Each flexible connection in fuel lines that may be under pressure or subjected to axial loading must use flexible hose assemblies.

(d) Flexible hose must be approved.

(e) No flexible hose that might be adversely affected by high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

§ 29.995 Fuel valves.

In addition to meeting the requirements of § 29.1189, each fuel valve must—

(a) [Reserved]

the fuel tank outlet and the inlet of the first fuel system component which is susceptible to fuel contamination, including but not limited to the fuel metering device or an engine positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain, except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections; and

(d) Provide a means to remove from the fuel any contaminant which would jeopardize the flow of fuel through rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system operation.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-10, Eff. 10/31/74); (Amdt. 29-22, Eff. 3/26/84); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.999 Fuel system drains.

(a) There must be at least one accessible drain at the lowest point in each fuel system to completely drain the system with the rotorcraft in any ground attitude to be expected in service.

(b) Each drain required by paragraph (a) of this section including the drains prescribed in § 29.971 must—

(1) Discharge clear of all parts of the rotorcraft;

(2) Have manual or automatic means to ensure positive closure in the off position; and

(3) Have a drain valve—

(i) That is readily accessible and which can be easily opened and closed; and

lowing apply:

(a) Fuel jettisoning must be safe during all flight regimes for which jettisoning is to be authorized.

(b) In showing compliance with paragraph (a) of this section, it must be shown that—

(1) The fuel jettisoning system and its operation are free from fire hazard;

(2) No hazard results from fuel or fuel vapors which impinge on any part of the rotorcraft during fuel jettisoning; and

(3) Controllability of the rotorcraft remains satisfactory throughout the fuel jettisoning operation.

(c) Means must be provided to automatically prevent jettisoning fuel below the level required for an all-engine climb at maximum continuous power from sea level to 5,000 feet altitude and cruise thereafter for 30 minutes at maximum range engine power.

(d) The controls for any fuel jettisoning system must be designed to allow flight personnel (minimum crew) to safely interrupt fuel jettisoning during any part of the jettisoning operation.

(e) The fuel jettisoning system must be designed to comply with the powerplant installation requirements of § 29.901(c).

(f) An auxiliary fuel jettisoning system which meets the requirements of paragraphs (a), (b), (d), and (e) of this section may be installed to jettison additional fuel provided it has separate and independent controls.

[(Amdt. 29-26, Eff. 10/3/88)]

OIL SYSTEM

§ 29.1011 Engines: General.

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation.

(b) The usable oil capacity of each system may not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum allowable oil consumption of the

tion of the engine.

(d) The ability of the engine oil cooling provisions to maintain the oil temperature at or below the maximum established value must be shown under the applicable requirements of §§ 29.1041 through 29.1049.

[(Amdt. 29-26, Eff. 10/3/88)]

§ 29.1013 Oil tanks.

(a) *Installation.* Each oil tank installation must meet the requirements of § 29.967.

(b) *Expansion space.* Oil tank expansion space must be provided so that—

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent of the tank capacity of 0.5 gallon, and each oil tank used with a turbine engine has an expansion space of not less than 10 percent of the tank capacity;

(2) Each reserve oil tank not directly connected to any engine has an expansion space of not less than 2 percent of the tank capacity; and

(3) It is impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

(c) *Filler connection.* Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have a drain that discharges clear of the entire rotorcraft. In addition—

(1) Each oil tank filler cap must provide an oil-tight seal under the pressure expected in operation;

(2) For category A rotorcraft, each oil tank filler cap or filler cap cover must incorporate features that provide a warning when caps are not fully locked or seated on the filler connection; and

(3) Each oil filler must be marked under § 29.1557(c)(2).

(d) *Vent.* Oil tanks must be vented as follows:

(1) Each oil tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions.

temperature. There must be a shutoff valve at the outlet of each oil tank used with a turbine engine unless the external portion of the oil system (including oil tank supports) is fireproof.

(f) *Flexible liners.* Each flexible oil tank liner must be approved or shown to be suitable for the particular installation.

[(Amdt. 29-10, Eff. 10/31/74)]

§ 29.1015 Oil tank tests.

Each oil tank must be designed and installed so that—

(a) It can withstand, without failure, any vibration, inertia, and fluid loads to which it may be subjected in operation; and

(b) It meets the requirements of § 29.965, except that instead of the pressure specified in § 29.965(b)—

(1) For pressurized tanks used with a turbine engine, the test pressure may not be less than 5 p.s.i. plus the maximum operating pressure of the tank; and

(2) For all other tanks, the test pressure may not be less than 5 p.s.i.

[(Amdt. 29-10, Eff. 10/31/74)]

§ 29.1017 Oil lines and fittings.

(a) Each oil line must meet the requirements of § 29.993.

(b) Breather lines must be arranged so that—

(1) Condensed water vapor that might freeze and obstruct the line cannot accumulate at any point;

(2) The breather discharge will not constitute a fire hazard if foaming occurs, or cause emitted oil to strike the pilot's windshield; and

(3) The breather does not discharge into the engine air induction system.

§ 29.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all

established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 29.1305(a)(18).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked. [(Amdt. 29-10, Eff. 10/31/74); (Amdt. 29-22, Eff. 3/26/84); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1021 Oil system drains.

A drain (or drains) must be provided to allow safe drainage of the oil system. Each drain must—

(a) Be accessible; and

(b) Have manual or automatic means for positive locking in the closed position.

[(Amdt. 29-22, Eff. 3/26/84)]

§ 29.1023 Oil radiators.

(a) Each oil radiator must be able to withstand any vibration, inertia, and oil pressure loads to which it would be subjected in operation.

(b) Each oil radiator air duct must be located, or equipped, so that, in case of fire, and with the

(c) Each oil valve must have positive stops or suitable index provisions in the “on” and “off” positions and must be supported so that no loads resulting from its operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

§ 29.1027 Transmission and gearboxes:

General.

(a) The oil system for components of the rotor drive system that require continuous lubrication must be sufficiently independent of the lubrication systems of the engine(s) to ensure—

(1) Operation with any engine inoperative; and

(2) Safe autorotation.

(b) Pressure lubrication systems for transmissions and gearboxes must comply with the requirements of §§ 29.1013, paragraphs (c), (d), and (f) only, 29.1015, 29.1017, 29.1021, 29.1023, and 29.1337(d). In addition, the system must have—

(1) An oil strainer or filter through which all the lubricant flows, and must—

(i) Be designed to remove from the lubricant any contaminant which may damage transmission and drive system components or impede the flow of lubricant to a hazardous degree; and

(ii) Be equipped with a bypass constructed and installed so that—

(A) The lubricant will flow at the normal rate through the rest of the system with the strainer or filter completely blocked; and

(B) The release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flowpath;

(iii) Be equipped with a means to indicate collection of contaminants on the filter or strainer at or before opening of the bypass;

(2) For each lubricant tank or sump outlet supplying lubrication to rotor drive systems and rotor drive system components, a screen to prevent entrance into the lubrication system of any object that might obstruct the flow of lubricant from the outlet to the filter required by paragraph

§ 29.1041 General.

(a) The powerplant and auxiliary power unit cooling provisions must be able to maintain the temperatures of power plant components, engine fluids, and auxiliary power unit components and fluids within the temperature limits established for these components and fluids, under ground, water, and flight operating conditions for which certification is requested, and after normal engine or auxiliary power shutdown, or both.

(b) There must be cooling provisions to maintain the fluid temperatures in any power transmission within safe values under any critical surface (ground or water) and flight operating conditions.

(c) Except for ground-use-only auxiliary power units, compliance with paragraphs (a) and (b) of this section must be shown by flight tests in which the temperatures of selected powerplant component and auxiliary power unit component, engine, and transmission fluids are obtained under the conditions prescribed in those paragraphs.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1043 Cooling tests.

(a) *General.* For the tests prescribed in § 29.1041(c), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b) of this section, the recorded powerplant temperatures must be corrected under paragraphs (c) and (d) of this section, unless a more rational correction method is applicable.

(2) No corrected temperature determined under paragraph (a)(1) of this section may exceed established limits.

(3) The fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those used in normal operation.

(4) The test procedures must be as prescribed in §§ 29.1045 through 29.1049.

ture of -69.7 degrees F. is reached, above which altitude the temperature is considered constant at -69.7 degrees F. However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 100 degrees F.

(c) *Correction factor (except cylinder barrels).* Unless a more rational correction applies, temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recorded during the cooling test.

(d) *Correction factor for cylinder barrel temperatures.* Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

[(Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-15, Eff. 3/1/78); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1045 Climb cooling test procedures.

(a) Climb cooling tests must be conducted under this section for—

(1) Category A rotorcraft; and

(2) Multiengine category B rotorcraft for which certification is requested under the category A powerplant installation requirements, and under the requirements of § 29.861(a) at the steady rate of climb or descent established under § 29.67(b).

(b) The climb or descent cooling tests must be conducted with the engine inoperative that produces the most adverse cooling conditions for the remaining engines and powerplant components.

(c) Each operating engine must—

(1) For helicopters for which the use of 30-minute OEI power is requested, be at 30-minute OEI power for 30 minutes, and then at maximum

the critical altitude).

(d) After temperatures have stabilized in flight, the climb must be—

(1) Begun from an altitude not greater than the lower of—

(i) 1,000 feet below the engine critical altitude; and

(ii) 1,000 feet below the maximum altitude at which the rate of climb is 150 f.p.m.; and

(2) Continued for at least 5 minutes after the occurrence of the highest temperature recorded, or until the rotorcraft reaches the maximum altitude for which certification is requested.

(e) For category B rotorcraft without a positive rate of climb, the descent must begin at the all-engine-critical altitude and end at the higher of—

(1) The maximum altitude at which level flight can be maintained with one engine operative; and

(2) Sea level.

(f) The climb or descent must be conducted at an airspeed representing a normal operational practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speeds established under § 29.67(a)(2) or § 29.67(b). The climb cooling test may be conducted in conjunction with the takeoff cooling test of § 29.1047.

[(Amdt. 29-1, Eff. 8/12/65); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1047 Takeoff cooling test procedures.

(a) *Category A.* For each category A rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(4) At the end of the time interval prescribed in paragraph (b)(3) of this section, the power must be changed to that used in meeting § 29.67(a)(2) and the climb must be continued for—

(i) Thirty minutes, if 30-minute OEI power is used; or

(ii) At least 5 minutes after the occurrence of the highest temperature recorded, if continuous OEI power or maximum continuous power is used.

(5) The speeds must be those used in determining the takeoff flight path under § 29.59.

(b) *Category B.* For each category B rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(2) After the temperatures have stabilized, a climb must be started at the lowest practicable altitude with takeoff power.

(3) Takeoff power must be used for the same time interval as takeoff power is used in determining the takeoff flight path under § 29.63.

(4) At the end of the time interval prescribed in paragraph (a)(3) of this section, the power must be reduced to maximum continuous power and the climb must be continued for at least five minutes after the occurrence of the highest temperature recorded.

(5) The cooling test must be conducted at an airspeed corresponding to normal operating practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speed for best rate of climb with maximum continuous power.

[(Amdt. 29-1, Eff. 8/12/65); (Amdt. 29-26, Eff. 10/3/88)]

after the occurrence of the highest temperature recorded; and

(b) With maximum continuous power, maximum weight, and at the altitude resulting in zero rate of climb for this configuration, until at least five minutes after the occurrence of the highest temperature recorded.

INDUCTION SYSTEM

§ 29.1091 Air induction.

(a) The air induction system for each engine and auxiliary power unit must supply the air required by that engine and auxiliary power unit under the operating conditions for which certification is requested.

(b) Each engine and auxiliary power unit air induction system must provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) No air intake may open within the engine accessory section or within other areas of any powerplant compartment where emergence of back-fire flame would constitute a fire hazard.

(d) Each reciprocating engine must have an alternate air source.

(e) Each alternate air intake must be located to prevent the entrance of rain, ice, or other foreign matter.

(f) For turbine engine powered rotorcraft and rotorcraft incorporating auxiliary power units—

(1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents, or other components of flammable fluid systems from entering the engine or auxiliary power unit intake system; and

(2) The air inlet ducts must be located or protected so as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-17, Eff. 12/1/78)]

(1) Each rotorcraft with sea level engines using conventional venturi carburetors has a preheater that can provide a heat rise of 90° F.;

(2) Each rotorcraft with sea level engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 70° F.;

(3) Each rotorcraft with altitude engines using conventional venturi carburetors has a preheater that can provide a heat rise of 120° F.; and

(4) Each rotorcraft with altitude engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 100° F.

(b) *Turbine engines.* (1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)—

(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in appendix C of this part; and

(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.

(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30° F (between -9° and -1° C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.

(c) *Supercharged reciprocating engines.* For each engine having a supercharger to pressurize the air before it enters the carburetor, the heat rise in the air caused by that supercharging at any altitude may be utilized in determining compliance with paragraph (a) of this section if the heat rise utilized is that which will be available, automatically, for

Each carburetor air preheater must be designed and constructed to—

(a) Ensure ventilation of the preheater when the engine is operated in cold air;

(b) Allow inspection of the exhaust manifold parts that it surrounds; and

(c) Allow inspection of critical parts of the preheater itself.

§ 29.1103 Induction systems ducts and air duct systems.

(a) Each induction system duct upstream of the first stage of the engine supercharger and of the auxiliary power unit compressor must have a drain to prevent the hazardous accumulation of fuel and moisture in the ground attitude. No drain may discharge where it might cause a fire hazard.

(b) Each duct must be strong enough to prevent induction system failure from normal backfire conditions.

(c) Each duct connected to components between which relative motion could exist must have means for flexibility.

(d) Each duct within any fire zone for which a fire-extinguishing system is required must be at least—

(1) Fireproof, if it passes through any firewall; or

(2) Fire resistant, for other ducts, except that ducts for auxiliary power units must be fireproof within the auxiliary power unit fire zone.

(e) Each auxiliary power unit induction system duct must be fireproof for a sufficient distance upstream of the auxiliary power unit compartment to prevent hot gas reverse flow from burning through auxiliary power unit ducts and entering any other compartment or area of the rotorcraft in which a hazard would be created resulting from the entry of hot gases. The materials used to form the remainder of the induction system duct and plenum chamber of the auxiliary power unit must be capable of resisting the maximum heat conditions likely to occur.

(f) Each auxiliary power unit induction system duct must be constructed of materials that will not

rotor,
(b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless it can be deiced by heated air;

(c) No screen may be deiced by alcohol alone; and

(d) It must be impossible for fuel to strike any screen.

§ 29.1107 Inter-coolers and after-coolers.

Each inter-cooler and after-cooler must be able to withstand the vibration, inertia, and air pressure loads to which it would be subjected in operation.

§ 29.1109 Carburetor air cooling.

It must be shown under § 29.1043 that each installation using two-stage superchargers has means to maintain the air temperature, at the carburetor inlet, at or below the maximum established value.

EXHAUST SYSTEM

§ 29.1121 General.

For powerplant and auxiliary power unit installations the following apply:

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

(b) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluids or vapors on any part of the exhaust system including shields for the exhaust system.

(c) Each component upon which hot exhaust gases could impinge, or that could be subjected to high temperatures from exhaust system parts, must be fireproof. Each exhaust system component must be separated by a fireproof shield from adjacent parts of the rotorcraft that are outside the engine and auxiliary power unit compartments.

(g) Each exhaust shroud must be ventilated or insulated to avoid, during normal operation, a temperature high enough to ignite any flammable fluids or vapors outside the shroud.

(h) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the rotorcraft, in any normal ground and flight attitudes, to prevent fuel accumulation after the failure of an attempted engine start.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-13, Eff. 5/2/77)]

§ 29.1123 Exhaust piping.

(a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operation.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

§ 29.1125 Exhaust heat exchangers.

For reciprocating engine powered rotorcraft the following apply:

(a) Each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia, and other loads to which it would be subjected in operation. In addition—

(1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases;

(2) There must be means for inspecting the critical parts of each exchanger;

(3) Each exchanger must have cooling provisions wherever it is subject to contact with exhaust gases; and

(4) Each exhaust heat exchanger muff may have stagnant areas or liquid traps that would increase the probability of ignition of flammable fluids or vapors that might be present in case of the failure or malfunction of components carrying flammable fluids.

POWERPLANT CONTROLS AND ACCESSORIES

§ 29.1141 Powerplant controls: General.

(a) Powerplant controls must be located and arranged under § 29.777 and marked under § 29.1555.

(b) Each control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in the cockpit.

(c) Each flexible powerplant control must be approved.

(d) Each control must be able to maintain any set position without—

(1) Constant attention; or

(2) Tendency to creep due to control loads or vibration.

(e) Each control must be able to withstand operating loads without excessive deflection.

(f) Controls of powerplant valves required for safety must have—

(1) For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and

(2) For power-assisted valves, a means to indicate to the flight crew when the valve—

(i) Is in the fully open or fully closed position; or

(ii) Is moving between the fully open and fully closed position.

[(Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1142 Auxiliary power unit controls.

Means must be provided on the flight deck for starting, stopping, and emergency shutdown of each installed auxiliary power unit.

[(Amdt. 29-17, Eff. 12/1/78)]

§ 29.1143 Engine controls.

(a) There must be a separate power control for each engine.

control. However, the injection system pump may have a separate control.

(e) if a power control incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. The means must—

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shutoff position.

[(f) For rotorcraft to be certificated for a 30-second OEI power rating, a means must be provided to automatically activate and control the 30-second OEI power and prevent any engine from exceeding the installed engine limits associated with the 30-second OEI power rating approved for the rotorcraft.]

(Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-26, Eff. 10/3/88); [(Amdt. 29-34, Eff. 10/17/94)]

§ 29.1145 Ignition switches.

(a) Ignition switches must control each ignition circuit on each engine.

(b) There must be means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines with continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation.

[(Amdt. 29-13, Eff. 5/2/77)]

§ 29.1147 Mixture controls.

(a) If there are mixture controls, each engine must have a separate control, and the controls must be arranged to allow—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(b) Each intermediate position of the mixture controls that corresponds to a normal operating setting must be identifiable by feel and sight.

There must be a separate carburetor air temperature control for each engine.

§ 29.1159 Supercharger controls.

Each supercharger control must be accessible to—

(a) The pilots; or

(b) (If there is a separate flight engineer station with a control panel) the flight engineer.

§ 29.1163 Powerplant accessories.

(a) Each engine mounted accessory must—

(1) Be approved for mounting on the engine involved;

(2) Use the provisions on the engine for mounting; and

(3) Be sealed in such a way as to prevent contamination of the engine oil system and the accessory system.

(b) Electrical equipment subject to arcing or sparking must be installed to minimize the probability of igniting flammable fluids or vapors.

(c) If continued rotation of an engine-driven cabin supercharger or any remote accessory driven by the engine will be a hazard if they malfunction, there must be means to prevent their hazardous rotation without interfering with the continued operation of the engine.

(d) Unless other means are provided, torque limiting means must be provided for accessory drives located on any component of the transmission and rotor drive system to prevent damage to these components from excessive accessory load.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-22, Eff. 3/26/84); (Amdt. 29-26, Eff. 10/3/88)]

§ 29.1165 Engine ignition systems.

(a) Each battery ignition system must be supplemented with a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.

tery with the generator running at its normal operating speed; and

(3) The condition of a completely depleted battery with the generator operating at idling speed, if there is only one battery.

(d) Magneto ground wiring (for separate ignition circuits) that lies on the engine side of any firewall must be installed, located, or protected to minimize the probability of the simultaneous failure of two or more wires as a result of mechanical damage, electrical fault, or other cause.

(e) No ground wire for any engine may be routed through a fire zone of another engine unless each part of that wire within that zone is fireproof.

(f) Each ignition system must be independent of any electrical circuit that is not used for assisting, controlling, or analyzing the operation of that system.

(g) There must be means to warn appropriate crewmembers if the malfunctioning of any part of the electrical system is causing the continuous discharge of any battery necessary for engine ignition.

[(Amdt. 29-12, Eff. 2/1/77)]

POWERPLANT FIRE PROTECTION

§ 29.1181 Designated fire zones: Regions included.

(a) Designated fire zones are—

(1) The engine power section of reciprocating engines;

(2) The engine accessory section of reciprocating engines;

(3) Any complete powerplant compartment in which there is no isolation between the engine power section and the engine accessory section, for reciprocating engines;

(4) Any auxiliary power unit compartment;

(5) Any fuel-burning heater and other combustion equipment installation described in § 29.859;

(6) The compressor and accessory sections of turbine engines; and

(7) The combustor, turbine, and tailpipe sections of turbine engine installations except sec-

§ 29.1183 Lines, fittings, and components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 25-quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) of this section does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in or add to, a fire hazard.

[(Amdt. 29-2, Eff. 6/4/67); (Amdt. 29-10, Eff. 10/31/74); (Amdt. 29-22, Eff. 3/26/84)]

§ 29.1185 Flammable fluids.

(a) No tank or reservoir that is part of a system containing flammable fluids or gases may be in a designated fire zone unless the fluid contained, the design of the system, the materials used in the tank and its supports, the shutoff means, and the connections, lines, and controls provide a degree of safety equal to that which would exist if the tank or reservoir were outside such a zone.

(b) Each fuel tank must be isolated from the engines by a firewall or shroud.

(c) There must be at least one-half inch of clear airspace between each tank or reservoir and each firewall or shroud isolating a designated fire zone, unless equivalent means are used to prevent heat transfer from the fire zone to the flammable fluid.

component containing flammable fluids. The drainage means must be—

(1) Effective under conditions expected to prevail when drainage is needed; and

(2) Arranged so that no discharged fluid will cause an additional fire hazard.

(b) Each designated fire zone must be ventilated to prevent the accumulation of flammable vapors.

(c) No ventilation opening may be where it would allow the entry of flammable fluids, vapors, or flame from other zones.

(d) Ventilation means must be arranged so that no discharged vapors will cause an additional fire hazard.

(e) For category A rotorcraft, there must be means to allow the crew to shut off the sources of forced ventilation in any fire zone (other than the engine power section of the powerplant compartment) unless the amount of extinguishing agent and the rate of discharge are based on the maximum airflow through that zone.

§ 29.1189 Shutoff means.

(a) There must be means to shut off or otherwise prevent hazardous quantities of fuel, oil, de-icing fluid, and other flammable fluids from flowing into, within, or through any designated fire zone, except that this means need not be provided—

(1) For lines, fittings, and components forming an integral part of an engine;

(2) For oil systems for turbine engine installations in which all components of the oil system, including oil tanks, are fireproof or located in areas not subject to engine fire conditions; or

(3) For engine oil systems in category B rotorcraft using reciprocating engines of less than 500 cubic inches displacement.

(b) The closing of any fuel shutoff valve for any engine may not make fuel unavailable to the remaining engines.

(c) For category A rotorcraft, no hazardous quantity of flammable fluid may drain into any designated fire zone after shutoff has been accomplished, nor may the closing of any fuel shutoff

a designated fire zone.

(f) Except for ground-use-only auxiliary power unit installations, there must be means to prevent inadvertent operation of each shutoff and to make it possible to reopen it in flight after it has been closed.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-22, Eff. 3/26/84)]

§ 29.1191 Firewalls.

(a) Each engine, including the combustor, turbine, and tailpipe sections of turbine engine installations, must be isolated by a firewall, shroud, or equivalent means, from personnel compartments, structures, controls, rotor mechanisms, and other parts that are—

(1) Essential to controlled flight and landing; and

(2) Not protected under § 29.861.

(b) Each auxiliary power unit, combustion heater, and other combustion equipment to be used in flight, must be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

(c) Each firewall or shroud must be constructed so that no hazardous quantity of air, fluid, or flame can pass from any engine compartment to other parts of the rotorcraft.

(d) Each opening in the firewall or shroud must be sealed with close-fitting fireproof grommets, bushings, or firewall fittings.

(e) Each firewall and shroud must be fireproof and protected against corrosion.

(f) In meeting this section, account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

[(Amdt. 29-3, Eff. 2/25/68)]

§ 29.1193 Cowling and engine compartment covering.

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(d) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

(e) Each rotorcraft must—

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet the requirements of paragraph (e)(1) of this section with the landing gear retracted (if applicable); and

(3) Have fireproof skin in areas subject to flame if a fire starts in or burns out of any designated fire zone.

(f) A means of retention for each openable or readily removable panel, cowling, or engine or rotor drive system covering must be provided to preclude hazardous damage to rotors or critical control components in the event of—

(1) Structural or mechanical failure of the normal retention means, unless such failure is extremely improbable; or

(2) Fire in a fire zone, if such fire could adversely affect the normal means of retention.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-26, Eff. 10/3/88)]

§29.1194 Other surfaces.

All surfaces aft of, and near, engine compartments and designated fire zones, other than tail surfaces not subject to heat flames, or sparks emanating from a designated fire zone or engine compartment, must be at least fire resistant.

[(Amdt. 29-3, Eff. 2/25/68)]

§29.1195 Fire extinguishing systems.

(a) Each turbine engine powered rotorcraft and Category A reciprocating engine powered rotorcraft, and each Category B reciprocating engine powered rotorcraft with engines of more than 1,500 cubic inches must have a fire extinguishing system for the designated fire zones. The fire extinguishing

(2) For each other designated fire zone, provide two adequate discharges.

(c) For single engine rotorcraft, the quantity of extinguishing agent and the rate of discharge must provide at least one adequate discharge for the engine compartment.

(d) It must be shown by either actual or simulated flight tests that under critical airflow conditions in flight the discharge of the extinguishing agent in each designated fire zone will provide an agent concentration capable of extinguishing fires in that zone and of minimizing the probability of reignition.

[(Amdt. 29-3, Eff. 2/25/68); (Amdt. 29-13, Eff. 5/2/77); (Amdt. 29-17, Eff. 12/1/78)]

§29.1197 Fire extinguishing agents.

(a) Fire extinguishing agents must—

(1) Be capable of extinguishing flames emanating from any burning of fluids or other combustible materials in the area protected by the fire extinguishing system; and

(2) Have thermal stability over the temperature range likely to be experienced in the compartment in which they are stored.

(b) If any toxic extinguishing agent is used it must be shown by test that entry of harmful concentrations of fluid or fluid vapors into any personnel compartment (due to leakage during normal operation of the rotorcraft, or discharge on the ground or in flight) is prevented, even though a defect may exist in the extinguishing system.

(c) [Deleted]

[(Amdt. 29-12, Eff. 2/1/77); (Amdt. 29-13, Eff. 5/2/77)]

§29.1199 Extinguishing agent containers.

(a) Each extinguishing agent container must have a pressure relief to prevent bursting of the container by excessive internal pressures.

(b) The discharge end of each discharge line from a pressure relief connection must be located so that discharge of the fire extinguishing agent would not damage the rotorcraft. The line must

prevent the pressure in the container from—

(1) Falling below that necessary to provide an adequate rate of discharge; or

(2) Rising high enough to cause premature discharge.

[(Amdt. 29-13, Eff. 5/2/77)]

§ 29.1201 Fire extinguishing system materials.

(a) No materials in any fire extinguishing system may react chemically with any extinguishing agent so as to create a hazard.

(b) Each system component in an engine compartment must be fireproof.

§ 29.1203 Fire detector systems.

(a) For each turbine engine powered rotorcraft and category A reciprocating engine powered rotorcraft, and for each category B reciprocating engine powered rotorcraft with engines of more than 900

ation.

(c) No fire detector may be affected by any oil, water, other fluids, or fumes that might be present.

(d) There must be means to allow crewmembers to check, in flight, the functioning of each fire detector system electrical circuit.

(e) The wiring and other components of each fire detector system in an engine compartment must be at least fire resistant.

(f) No fire detector system component for any fire zone may pass through another fire zone, unless—

(1) It is protected against the possibility of false warnings resulting from fires in zones through which it passes; or

(2) The zones involved are simultaneously protected by the same detector and extinguishing systems.

[(Amdt. 29-3, Eff. 2/25/68)]

